X'trapolis for Perth

Environmental Product Declaration in accordance with ISO 14025

Programme operator: EPD International AB
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ALSTOM
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Transperth
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Alstom, at the forefront of sustainability

Alstom develops and offers a range of systems, equipment and services for the rail sector and key to its mission is supporting the transition towards global sustainable transport systems that are inclusive, safe and efficient.

As a promoter of sustainable mobility, Alstom places environmental issues at the heart of its R&D strategy, constantly designing solutions and products which are less energy-consuming, quicker to install, cheaper to maintain, and with higher lifespan and reduced carbon footprint.

For more than 25 years, the company has worked systematically by introducing Ecodesign in its engineering procedures.

Today, Alstom can rely on a team of Ecodesign engineers to ensure the environmental performance of its portfolio and its ability to develop innovative solutions tackling key environmental challenges.

Sustainable mobility

Alstom's mission is to support the transition to sustainable transport systems by delivering mobility solutions that are safe, environmentally friendly, reliable and inclusive everywhere in the world.

ISO 14001

Environmental Management

Alstom has an environmental management system fully in place and targets 100 % of manufacturing sites and regional centers with over 200 employees to be certified according to ISO 14001:2015 Standard for Environmental management.

In the environmental management system, Alstom is including the life cycle perspective of products, from concept to recycling including maintenance and energy consumption. Alstom offers innovative solutions that respect the environment and meet the mobility needs according to a socially responsible model.

To continuously improve Alstom products and ways of working, environmental targets for sites and products are implemented and regularly evolved following return of experience and best practice.

ISO 14025

Communicating Environmental Performance

Alstom communicate the environmental performance of products through Environmental Product Declarations (EPDs) following the International EPD® System. EPDs are developed in line with the Product Category Rules for Rolling Stock (PCR 2009:05) as well as the principles and procedures of ISO 14025:2006.

They are based on Life Cycle Assessment methodology and function as an externally validated communication tool, providing complete transparency to the benefit of customers and other stakeholders. The external validation is carried out by independent verifiers approved by the technical committee of the International EPD® System.

Life cycle assessment (LCA) is a technique assessing the environmental impacts associated with all stages of a product's life cycle from cradle to grave (i.e., from raw material extraction through materials processing, manufacturing, distribution, use, repair and maintenance, and disposal or recycling).

X'trapolis for Perth

The X'trapolis™ product platform sets a high standard for environmentally sustainable commuter transportation. This Environmental Product Declaration provides a detailed insight into the environmental impact of the electrical multiple units (EMU) through their complete life cycle.

The X'trapolis for Perth is a proven solution with 5,500 cars sold across the world (of which 3,600 cars for PRASA, South Africa).

To Perth, Alstom delivers a total of 41 6-car electrical trains of X'trapolis next generation C-series version. Each train has 6 doors per car and is designed to transport 1184 passengers to meet the demand of the Perth commuter needs.

Product information

The X'trapolis EMU is the next generation of C-series trains for Perth's growing rail network. These trains are designed and built by Alstom, promoter of sustainable mobility at ISO 14001 certified sites at Perth, Australia (final assembly site) along with Sricity and Coimbatore in India as participating units. This product belongs to the Rolling Stock product category (UN CPC 495) and is delivered with this EPD owned by Alstom, 48, rue Albert Dhalenne, 93482 Saint-Ouen, Cedex France.

Key benefits

A safer environment

The vehicle is developed with **a strong emphasis on commitment** to eliminate hazardous substances in the product as well as during production, maintenance and end of life. In addition, emissions of the train have been controlled to ensure the safety of passenger, operators and environment. Globally these actions have permitted to provide a safer environment for our customers, passengers, employees and natural environments.

A satisfactory working environment

The cab is **optimized** and studied to provide a ergonomic working environment for the driver, including separate air conditioning control.

High capacity

Designed for high passenger flow, the train benefits from a **completely open design** , focusing on fluidity, comfort and security.

Accessibility

The vehicle is offering **inclusive** accessibility thanks to a floor without height differences throughout the train, and with no difference in height between the platform and the vehicle. Priority seats clearly distinguished by a specific color of seat fabric for instant identification. Flexible multipurpose areas for wheelchair users, parents with strollers, bulky luggage or standees, strollers or powered mobility devices users.

Main characteristics	Vehicle data
Type of vehicle	X'trapolis C-series EMU
Geographical scope/Operating location	Perth, Australia
Configuration	6 cars (4 motor cars + 2 trailer cars)
Expected service lifetime	35 years
Number of seats	336
Passengers' capacity	1184, all seats occupied and standing density of 4passengers/m2
Body shell	Stainless steel
Design mass under normal payload	339 000 kg
Car length	143 m
Total height	3 941 mm (4 200 mm with pantograph)
Maximum Design / commercial speed	130 km/h
Average commercial speed	53 km/h
Power supply type and voltage	Catenary, 25 kV AC
Wheel / Tyre type	Wheel (850 mm)
Temperature range	-25°C to +50°C, uncompromised performance till 46°C
Features	CCTV Cameras Air conditioning USB charging sockets

Carbody

Integrated welded structure of corrosion resistance stainless steel for crashworthiness, graffiti removal, resistance to chemical attack, aesthetic qualities and low maintenance requirements.

Comfort

Efficient air-conditioning and ventilation systems: adjustment of the air flow depending on the number of passengers present.

Propulsion and electrical equipment

Traction allows energy recovery during braking.

Material selection

Materials selected to be recoverable at end-of-life.

Life cycle description

Environment impacts of X'trapolis EMUs have been characterized through the realization of a cradle-to-grave LCA in accordance with ISO 14040:2006 and ISO 14044:2006 methodology, and the requirements of the GPI version 4.0 and the PCR: Rolling stock and parts thereof, UN CPC 495, 2009:05 version 4.0.1. The LCA for Experts Software (version 10.7.0) and Database (2023-1) with EF3.1 characterisation factors were used to perform this life cycle impact assessment.

Functional unit

The functional unit for the performed LCA is the transport of 1 passenger over 1 km, using a 6 car EMU in service for 35 years over 4 lines in Perth, with an average yearly running distance of 265 000 km.

Cut-off rules

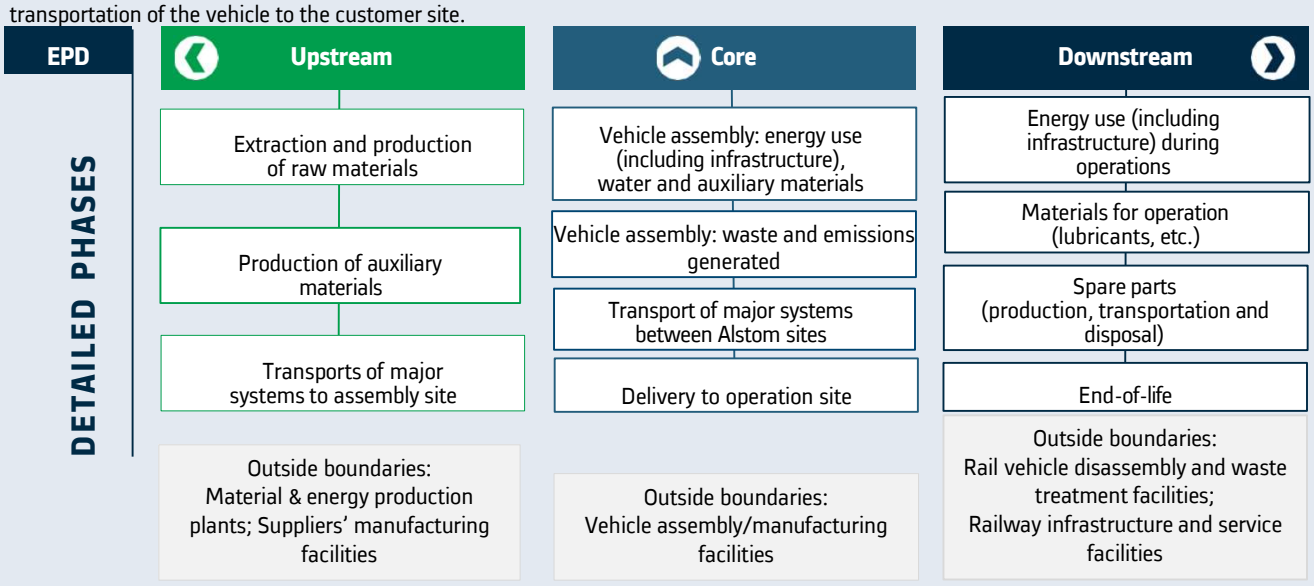
The exclusion rules applied are in line with the indications of the PCR for Rolling stock (PCR 2009:05).

Life cycle boundaries

Material and energy production data used for **the upstream module** is based on data from the supply chain and consider the specific recycled content. The impact of the use of hazardous substances in the product has also been evaluated. Transportation of vehicle sub-systems from direct suppliers to assembly sites is included.

The core module includes site specific data (for the period between the 1st of Jan 2022 to 31st of Dec 2022) covering the trainsets assembly in the site of Perth (Australia) and the components assembly in the site of Coimbatore and Sri City (India). This includes the electricity from solar in Australia & India for on-site electricity production, and the grid mix of Western Australia & the electricity from hydro power in India for off-site electricity production covered with RECS certificates. Included is also the transportation of sub-systems between Alstom sites and the final transportation of the vehicle to the customer site.

The power supply for the vehicle operation **in the downstream module** is the 2020 Western Australian national production grid mix. Data used for maintenance materials is based on the planned preventive maintenance of the vehicle over its entire service life. Emissions of particles are estimated from the wear rate of friction parts. The end-of-life is modelled in line with the ISO 21106:2002 methodology. The recyclability and recoverability potential of each material is assessed based on its nature, its integration in the trainset, and the technology available today. As a result, all metals and most single material polymers are considered as recyclable whereas most composite polymers are considered as recoverable only. It is assumed that the vehicle will be dismantled and disposed of in Australia.



Allocations

In the upstream module, no allocation is required except the allocations built into the databases of the LCA software. For the vehicle assembly in the core module, the impact of the production plant is allocated by number of manhours used, all activities combined.
Impacts and benefits of the recycling of waste are excluded from the scope of the study. Burden linked to incineration are included, but impact and benefits linked to the use of the energy from incineration are also excluded.

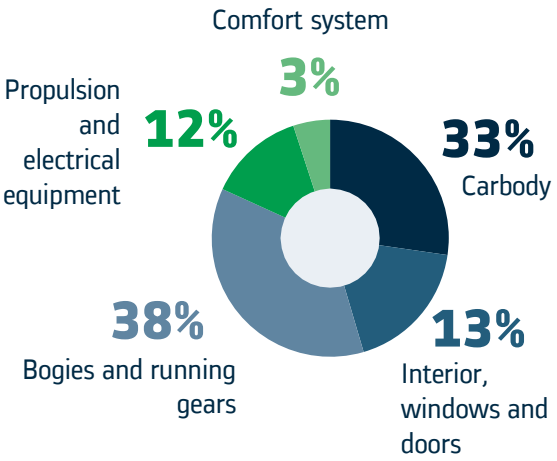
Data quality

Whenever possible, specific data was used. 99.31% of the mass of the train and the spare parts were inventoried with specific data, the rest being modelled according to the PCR 2009:05. Transport of components to assembly sites was done using specific data for 89.4% of the components, the remaining modelled by 500 km truck transport, in line with the PCR 2009:05. Transport of components between assembly sites was done using 100% specific data.

Content declaration

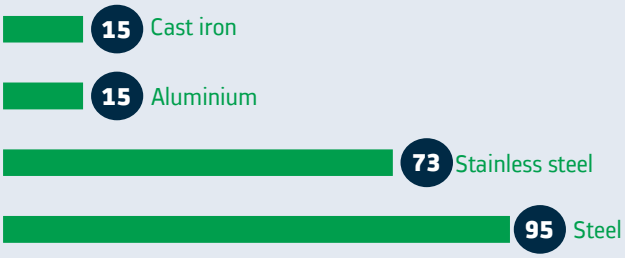
Rolling stock manufacturing

Share of mass by PCR categories



Rolling stock composition

Top four metals for manufacturing (metric tons)



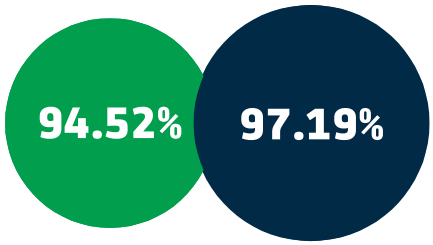
Bill of materials (mass in kg)	Upstream (vehicle)	Downstream (spare parts)*	TOTAL
Metals (ferrous or non-ferrous)	205 550	227 010	432 560
Elastomers	3 732	782	4 514
Polymers – filled and unfilled	3 869	779	4 648
Composites	2 043	759	2 802
Electric and Electronic Equipment (EEE)	13 318	3 779	17 097
Glass	55	0	55
Safety Glass	3 477	0	3 477
Oil, grease, etc.	1 331	7 905	9 236
Acids, cooling agents, etc.	97	0	97
Other inorganic materials (including ceramics)	4 630	6 808	11 438
Mineral wool	1 166	0	1 166
Modified Organic Natural Materials (MONM)	5 192	1 015	6 206
TOTAL	**244 460**	**248 837**	**493 297**

* The mass of materials in the downstream module is larger than in the upstream module due to the change of spare parts, i.e. wheelsets, brake pads, and other components occurring several times during the vehicle's lifetime

Hazardous substances

Alstom's standard for hazardous substances management considers European regulation (REACH) and railway sector principles through the RISL (Railway Industry Substances List), which has been considered during the design of the vehicle as well as for chemicals used during maintenance.

In some areas, use of hazardous substances according to RISL has not been avoidable due to functional and safety requirements, including lead in electronics as well as the refrigerant gas mix used for the air conditioning system. However, no hazardous substances are used in any prohibited application at the time of production of the EMU Perth.



Recyclability rate **Recoverability rate**

A recyclable solution

Using materials featuring high recyclability and considering disassembly early in the design phase maximise the overall recoverability of the X'trapolis EMU. Material recycling and energy recovery aggregate to a 97.19% recoverability rate by applying ISO 21106:2019 methodology.

Additional information

Energy consumption during operation

Energy consumption data is based on a simulation run on the up and down route **from Perth to Mandurah and Butler stations**, including all intermediate stops, in **hourly mode**. The power tension of the line is **25kV**.

The energy consumption is based on a **fully equipped vehicle, occupied with 1184 passengers per 6-car trainset (all seats occupied)**, and all auxiliary and passenger comfort systems operating. All assumptions on vehicle auxiliary systems load are following the methodology and operational profiles used for the energy consumption simulation. **The simulated operational scenarios features energy recovery from regenerative braking**.

	Operation
Number of passenger (for energy calculation)	1184
Energy consumption while running (per trip)	913.7 kWh (Mandurah Down) 926.7 kWh (Mandurah Up) 561.5 kWh (Butler Down) 497.5 kWh (Butler Up)
Distance travelled per year*	265 000 kms
Roundtrip distance (for energy calculation)	141.62 kms (Mandurah) 81.48 kms (Butler)
Total trips per year	935.7 (Perth-Mandurah) 1626.1 (Perth-Butler)
Operation time	355 days/year, 35 years

*The total mileage per train per line (up & down) = Anticipated mileage per train per year/Number of lines under consideration i.e., 265 000/4 = 66 250 kms

The total energy consumption for use phase across the four lines for the entire lifetime is equal to **120 541 025 kWh/train**

The **PCR for Rolling Stock (PCR 2009:05)** stipulates that for the electricity consumed during the downstream module, the impacts of the production of electricity must be calculated **first** using the **specific data of the electricity as produced or purchased**, then at the **using the residual national electricity mix**, and finally, if the first two models are not possible, using **the national electricity mix**.

However, no residual electricity mix data was available in LCA for experts when the calculation was performed. Thus, the choice was made for the entire scope, to use the **2020 Western Australian electricity grid mix for transferring 1kV-60kV** with an emission factor of **0.748kgCO2eq./ kWh** supplied by LCA for Experts software. This approach appears to be conservative.

Noise emissions

	Unit	dB(A)
Stationary noise	LpAeq	61.5
Noise in preconditioning	LpAeq	67.7
Constant speed noise 80km/h	LpAeq, Tp (80km/h)	69.9
Acceleration (no contractual requirement)	LpAfmax	73.5

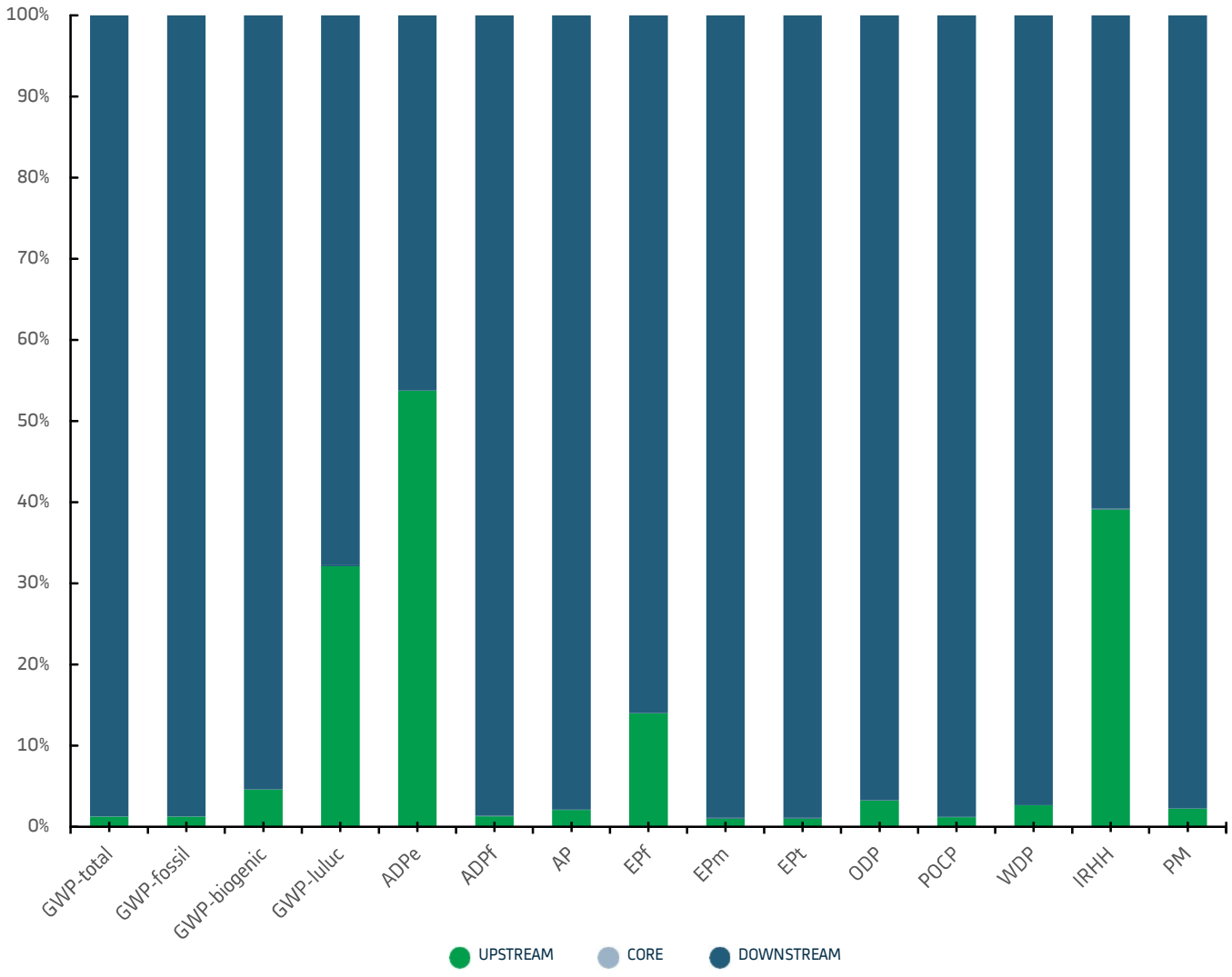
The noise levels for X'trapolis EMU were measured in accordance with the ISO 3095:2013.

Environmental performance

Contribution of each phase to the environmental impacts

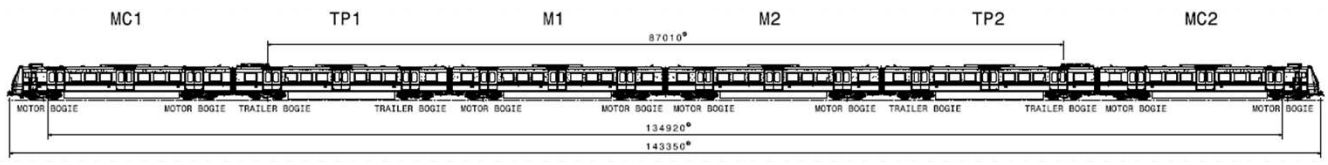
The relative contribution per functional unit from each phase of the life cycle of X'trapolis EMU

For most indicators, the downstream phase is responsible for the most significant part of the environmental impacts. This is especially due to the electricity consumption during the use of the train for the 35 years of its expected lifetime.



Configuration

Life cycle description information and environmental performance results published in this EPD correspond to the one of the design configurations developed by Alstom. To know the performance associated to other possible configurations of the solution, please contact Alstom.



Environmental impacts (per functional unit*)	Unit	Upstream	Core	Downstream	TOTAL
Global warming potential (GWP) – Total	kg CO_2 eq.	1.05E-04	3.86E-06	8.17E-03	**8.28E-03**
Global warming potential (GWP) – Fossil	kg CO_2 eq.	1.05E-04	3.86E-06	8.17E-03	**8.28E-03**
Global warming potential (GWP) – Biogenic	kg CO_2 eq.	1.12E-07	1.56E-09	2.31E-06	**2.43E-06**
Global warming potential (GWP) - Land use and land transformation	kg CO_2 eq.	1.72E-07	1.11E-09	3.62E-07	**5.36E-07**
Abiotic depletion potential for minerals and metals (ADPe)[1]	kg Sb eq.	1.15E-08	3.56E-12	9.89E-09	**2.14E-08**
Abiotic depletion potential for fossil resources (APDf) [1]	MJ	1.38E-03	5.26E-05	1.03E-01	**1.04E-01**
Acidification potential (AP)	kg H+ eq.	8.52E-07	2.36E-08	4.01E-05	**4.10E-05**
Eutrophication potential, freshwater (EPf)	kg P eq.	1.71E-10	1.11E-12	1.05E-09	**1.22E-09**
Eutrophication potential, marine (EPm)	kg N eq.	1.02E-07	8.29E-09	9.70E-06	**9.81E-06**
Eutrophication potential, terrestrial (EPt)	mol N eq.	1.10E-06	9.08E-08	1.06E-04	**1.07E-04**
Ozone depletion potential (ODP)	kg CFC 11 eq.	4.37E-15	5.89E-17	1.30E-13	**1.35E-13**
Photochemical ozone creation potential (POCP)	kg NMVOC eq.	3.22E-07	3.66E-08	2.67E-05	**2.71E-05**
Water deprivation potential (WDP) [1]	m^3 eq.	4.22E-05	1.53E-06	1.53E-03	**1.58E-03**
Ionising Radiation – Human Health[2]	kgU235 eq.	5.10E-06	1.23E-08	7.84E-06	**1.30E-05**
Particulate Matter (PM)	Disease Incidence	1.24E-11	3.91E-13	4.99E-10	**5.12E-10**

Use of resources (per functional unit*)		Unit	Upstream	Core	Downstream	TOTAL
RENEWABLE RESOURCES						
Primary energy resources	Use as energy carrier	MJ, net calorific value	3,02E-04	1,68E-05	4,02E-02	**4,06E-02**
	Used as raw materials	MJ, net calorific value	1,05E-05	0,00E+00	4,98E-07	**1,10E-05**
	TOTAL	**MJ, net calorific value**	**3,13E-04**	**1,68E-05**	**4,02E-02**	**4,06E-02**
NON-RENEWABLE RESOURCES						
Primary energy resources	Use as energy carrier	MJ, net calorific value	1,33E-03	5,26E-05	1,03E-01	**1,04E-01**
	Used as raw materials	MJ, net calorific value	4,79E-05	0,00E+00	4,57E-05	**9,36E-05**
	TOTAL	**MJ, net calorific value**	**1,38E-03**	**5,26E-05**	**1,03E-01**	**1,04E-01**
Secondary material		kg	2,41E-06	0,00E+00	6,73E-06	**9,14E-06**
Renewable secondary fuels		MJ, net calorific value	1,21E-29	0,00E+00	1,47E-30	**1,36E-29**
Non-renewable secondary fuels		MJ, net calorific value	1,42E-28	0,00E+00	1,72E-29	**1,59E-28**
Net use of fresh water **		m3	2,85E-06	2,74E-08	2,32E-05	**2,61E-05**

* To convert the results to one unit of product, a conversion factor of **1.11E+10** shall be used

** The net use of fresh water does not constitute a "water footprint" as potential environmental impacts due to the water use in different geographical locations is not captured.

Waste (per functional unit*)	Unit	Upstream	Core	Downstream	TOTAL
Hazardous waste disposed	kg	4,51E-09	1,27E-11	7,03E-09	**1,16E-08**
Non-hazardous waste disposed	kg	9,32E-06	1,69E-07	3,88E-05	**4,83E-05**
Radioactive waste disposed	kg	3,41E-08	1,02E-10	5,96E-08	**9,38E-08**

Output flows (per functional unit*)	Unit	Upstream	Core	Downstream	TOTAL
Components for reuse	kg	0,00E+00	0,00E+00	0,00E+00	**0,00E+00**
Material for recycling	kg	0,00E+00	6,53E-07	4,31E-05	**4,38E-05**
Materials for energy recovery	kg	0,00E+00	7,28E-08	1,22E-06	**1,29E-06**
Exported energy, electricity	MJ	0,00E+00	1,43E-08	4,45E-06	**4,47E-06**
Exported energy, thermal	MJ	0,00E+00	2,96E-08	1,02E-05	**1,02E-05**

* To convert the results to one unit of product, a conversion factor of **1.11E+10** shall be used

Global warming potential

These indicators calculates the contribution to global warming of the planet by the emission of greenhouse gases. GWP is expressed as: GWP-fossil, GWP-biogenic, GWP-land use and land use change (luluc),and GWP-Total (the sum of the other three GWP indicators).
The result is expressed in kg CO2 equivalents.

Abiotic depletion potential for minerals and metals[1]

This indicator calculates the depletion of non-fossil resources.
The result is expressed in kg Sb equivalents.

Abiotic depletion potential for fossil resources[1]

This indicator calculates the depletion of fossil resources.
The result is expressed in MJ.

Acidification potential

This indicator calculates the potential atmospheric acidification caused by the emission of gas with an acidifying effect.
The result is expressed in kg SO2 equivalents.

Eutrophication potential

This indicator calculates the eutrophication potential of freshwater, marine water and terrestrial environment caused by the emission of specific substances (discharge of phosphoric, nitrogenous and organic matter).
The result is expressed in kg phosphate equivalents for freshwater eutrophication, in kg nitrate equivalents for marine water eutrophication and in mol nitrate equivalents for terrestrial eutrophication.

Ozone depletion potential

This indicator calculates the contribution made by the discharge of specific gases responsible for ozone layer depletion.
The result is expressed in kg CFC-11 equivalents.

Photochemical ozone creation potential

This indicator calculates the potential of certain gases (NOx, CO, VOCs, etc.) to create ozone in the troposphere under the effect of solar radiation.
The result is expressed in kg ethylene equivalents.

Water deprivation potential[1]

The indicator represents the potential to deprive human or ecosystem when consuming water in a considered area, considering both availability and demand.
The result is expressed in m3 equivalents.

Ionizing radiation – human health[2]

This indicator represents the emissions of radionuclides with damage to human health and ecosystems (generally linked to use of nuclear power in an electricity mix)
The result is expressed in kg U235 equivalents.

Particulate matter

Health impact of emissions of small particles and liquid droplets (e.g., organic chemicals, soil or dust particles)
The result is expressed in disease incidence.

[1] The results of this environmental impact indicator shall be used with care as the uncertainties of the results are high and as there is limited experience with the indicator.

[2] This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.

Programme information

This Environmental Product Declaration (EPD) is based on a product Life-Cycle Assessment according to ISO 14040:2006/ISO 14044:2006 and is compliant with the requirements set in ISO 14025:2006. Alstom, owner of the EPD, has the sole ownership, liability and responsibility of the EPD.

EPDs within the same product category but from different programmes may not be comparable. For two EPDs to be comparable, they must be based on the same PCR (including the same version number) or be based on fully aligned PCRs or versions of PCRs; cover products with identical functions, technical performances and use (e.g. identical declared/functional units); have equivalent system boundaries and descriptions of data; apply equivalent data quality requirements, methods of data collection, and allocation methods; apply identical cut-off rules and impact assessment methods (including the same version of characterisation factors); have equivalent content declarations; and be valid at the time of comparison.

Accountabilities for PCR, LCA and independent, third-party verification

Product category rules (PCR)

PCR: Rolling stock, PCR 2009:05, ver 4.0.1, UN CPC 495. PCR review was conducted by: The Technical Committee of the International EPD® System. Chair: Claudia A. Peña. The PCR review panel may be contacted via info@environdec.com.

Life cycle assessment (LCA)

LCA accountability	Deba Prakash GURU Alstom ecodesign@alstomgroup.com	**EPD owner**	Alstom 48, rue Albert Dhalenne 93482 Saint-Ouen, Cedex France

Third party verification

Independent verification of the declaration and data, according to ISO 14025:2006 via:

■ EPD verification by individual verifier

Third party verifier	Yannick LE GUERN Elys Conseil 11 rue de Ligoger 77580 GUERARD yannick.leguern@elys-conseil.com	**Approved by**	The International EPD® System

Procedure for follow-up of data during EPD validity involves third party verifier:

☐ Yes ■ No

Programme operation	EPD International AB, Box 210 60, SE-100 31 Stockholm, Sweden, E-mail: info@environdec.com
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Revision	First issue

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